SECTOR ASSESSMENT (SUMMARY) RENEWABLE ENERGY SUBSECTOR

Sector Road Map

1. Sector Performance, Problems, and Opportunities

1. The energy sector in the People's Republic of China (PRC) has grown rapidly in tandem with economic growth. Installed power capacity has expanded by about 70% since 2008.[1] The power sector depends heavily on coal-fired power generation, which accounts for 70% of total installed capacity and 76% of total power generation in the PRC in 2012. Its coal consumption has been a major source of carbon dioxide emissions, accounting for 50% of total carbon dioxide emissions in the PRC, although the carbon intensity of the energy sector has continuously declined diversifying the energy mix by promoting renewable energy is one of the core development strategy in the PRC to attain the carbon intensity reduction target, and address the challenges of climate change and energy security in the country.

Table 1: Current Energy Mix and Future Projection in the People's Republic of China

Energy Type	Capacity (GW)			Share (%)	Electricity Generation (TWh)			Share (%)
	2010	2015	2020	2020	2010	2015	2020	2020
Coal	671	885	982	54.2	3,297	4,410	4,759	63.9
Oil	15	11	11	0.6	13	14	13	0.2
Gas	35	72	106	5.9	83	211	346	4.6
Nuclear	11	33	70	3.9	74	248	539	7.2
Hydro	213	285	360	19.9	722	930	1,179	15.8
Bioenergy	6	13	30	1.7	11	46	145	1.9
Wind	45	123	200	11.0	45	218	393	5.3
Geothermal	0	0	1	0.1	0	1	3	0.0
Solar	1	21	53	3.0	1	29	70	1.0
Total	**997**	**1,444**	**1,811**	**100.0**	**4,247**	**6,107**	**7,447**	**100.0**

GW = gigawatt, TWh = terawatt-hour.
Notes: Numbers may not sum precisely because of rounding. Percentages may not total 100% because of rounding.
Sources: International Energy Agency. 2012. *World Energy Outlook 2012*. Paris; European Solar Thermal Electricity Association (ESTELA). 2012. *Solar Thermal Electricity in China in 2011 and Future Outlook*. Brussels.

2. The PRC's energy consumption is expected to reach 4.5 billion tons of coal equivalent (tce) and electricity consumption is expected to reach 7,447 terawatt-hours (TWh) by 2020, compared with 3.25 billion tce and about 4,000 TWh in 2010.[2] To transit to a low-carbon energy system, the share of renewable energy, such as wind and solar, in the generation mix has to increase. During the Eleventh Five-Year Plan, 2006–2010, the PRC witnessed rapid growth in wind power and solar photovoltaic development. During this period, the installed capacity of wind power increased from 1.3 gigawatts (GW) to 41.8 GW. Solar photovoltaic installed capacity also expanded, but more modestly, from 70 megawatts (MW) to 900 MW during the same period. However, it surged to 3.28 GW in 2012. The PRC has set a target of 21 GW solar photovoltaic capacity by 2015. By 2020, install capacity of wind energy is expected to reach more than 200 GW while solar energy capacity is expected to reach 53 GW.

3. The rapid development of solar photovoltaic and wind power capacity is posing new challenges to grid stability because of the intermittent nature of power supplied by these plants. For instance, the curtailment of wind power in certain regions of the PRC is as high as 45%,

[1] National Energy Administration. 2013. *Report on China's Energy Development for 2013*. Beijing: Economic Science Press.
[2] International Energy Agency. 2011. *Technology Roadmap: China Wind Energy Development Roadmap 2050*. Paris.

compared with less than 10% in Europe.[3] At higher penetration of solar photovoltaic and wind power generation, increased grid flexibility will be needed to fully utilize the variable and uncertain output from these plants. Extra high voltage transmission lines of 750 kilovolts (kV) or more are under construction to improve interconnection, which is expected to partially mitigate intermittency effects of wind and solar electricity. The development of predictable renewable energy sources, such as concentrated solar thermal power (CSP), will be essential to pursue a higher share of intermittent renewable energy without affecting grid stability.

4. CSP is an innovative solar technology that produces high temperature heat by capturing and concentrating direct sunlight, generally referred to as direct normal irradiation, and using this heat to generate electricity through conventional steam turbines. CSP plants have inherent capacity to store surplus heat energy in thermal storage for sufficiently long periods of time (currently up to 15 hours in operation), and can be equipped with a natural gas backup system to generate electricity when there is not enough solar irradiation. CSP is an alternative to fossil fuel power plants to supply reliable and predictable electricity at any time of day. It also enables grid operators to schedule their dispatch economically, which enhances grid stability.

5. By 2012, global installed capacity of CSP exceeded 2.5 GW, and an additional 2.4 GW are under construction around the globe, mainly in Spain and the United States. Although it has abundant solar resources, the PRC is still at an early stage of adopting this technology, with no utility-scale (≥10 MW) plant in operation. For instance, more than 700,000 square kilometers (km^2) are suitable for CSP installation, with potential generation of more than 51,000 TWh of electricity per year,[4] compared with the PRC's total electricity generation of 4,980 TWh in 2012. Recent Asian Development Bank (ADB) capacity development technical assistance (TA)[5] estimated that if CSP is deployed in a timely manner in provinces such as Gansu and Qinghai, it could provide 15% of the total electricity by 2040.

6. This is based on CSP diffusion scenarios of 0.3–4.0 GW of install capacity at the demonstration stage (2012–2017), 2.4–18.0 GW at market penetration (2017–2022), 6.0–62.0 GW at market growth (2022–2027), and 42–140 GW at market expansion (2027 onward). With larger capacity addition, CSP can attain grid parity by 2030.[6] Accelerating CSP development at the penetration stage (2012–2017) is crucial to put CSP technology deployment on this trajectory. However, utility-scale CSP is at an early stage of development in the PRC primarily because of limited hands-on experience with the technology. Other factors such as extreme cold climate and water scarcity conditions prevalent in the suitable locations for CSP, combined with insufficient tariff support,[7] have limited investment in CSP—causing delays in CSP demonstration and deployment in the PRC.

2. Government's Sector Strategy

7. Climate change concerns and scarcity of fossil fuel resources have made the diversification of the energy mix, especially expansion of nonpolluting power generation, one of

[3] Non-absorption of electricity generated by wind power plants via the power system dispatch center.
[4] ADB. 2011. *Final Report on Concentrating Solar Thermal Power Development*. Consultant's report. Manila (TA 7402-PRC).
[5] ADB. 2009. *Technical Assistance to the People's Republic of China for Concentrating Solar Thermal Power Development*. Manila (TA 7402-PRC).
[6] This is based on a reduction in cost resulting from economy of scale and learning factors. The baseline grid tariff is expected to be CNY0.6 per kilowatt-hour (kWh) by 2030.
[7] The feed-in tariff introduced in 2011 is for solar photovoltaic. Uncertainties relate to the CSP tariff. The Government of the PRC is expected to issue a new feed-in tariff for CSP in 2014.

the top government priorities in the PRC. In 2005, the Renewable Energy Law was enacted to kick-start large-scale renewable energy development in the country. It provides a set of incentives to promote some non-hydro renewable technologies, specifies grid feed-in requirements and standard procedures, and establishes supervisory measures. In 2007, the National Development and Reform Commission issued the Medium and Long-Term Development Plan for Renewable Energy in the PRC, which aims to increase the share of renewable energy in total primary energy consumption to 15% by 2020. The Twelfth Five-Year Plan has set targets to increase the share of renewable energy from 8.9% in 2010 to 11.4% in 2015, and decrease carbon intensity by 17% by 2015 compared with 2010 levels. The PRC will attain 644 GW of renewable energy installed capacity by 2020, with 1,790 TWh of electricity generation—accounting for 35.5% of total installed capacity and 24.0% of total power generation in 2020.

8. The government has set a target for solar energy capacity of 21 GW (including 1 GW of CSP) by 2015, and 53 GW (including 3 GW of CSP) by 2020. With strong domestic production capacity and government policy support, solar photovoltaic installed capacity has been growing rapidly since 2009. The government launched the first concession program for a 10 MW grid-connected solar photovoltaic plant in Gansu Province in 2009, and initiated the nationwide grid-connected solar photovoltaic concession program with 280 MW total installed capacity in 2010. Since 2009, the offtake tariff of solar photovoltaic power generation has declined, and the government announced the CNY1.0 per kilowatt-hour (kWh) feed-in tariff for solar photovoltaic in 2011. The generation cost of solar photovoltaic in the PRC is projected to decline by 8% per annum, in line with the domestic market growth, and will achieve grid parity by 2020.[8]

9. Qinghai Province is located in the northeastern part of the Qinghai-Xizang plateau in the western PRC. With about 2,100 kWh per square meter per year of rich solar irradiation resource, it is the fastest growing region for solar power development in the PRC. Its solar photovoltaic installed capacity reached 2,010 MW in 2012—62.5% of the total solar photovoltaic installed capacity in the PRC. Qinghai Province will remain one of the major incubators of solar power in the country. Qinghai provincial government targets expanding solar energy development to 4 GW by 2015, including 300 MW of CSP; and to 10 GW by 2020, including 2 GW of CSP. This will account for about 20% of the national targets.

10. In 2010, the government conducted the first concession bidding for 50 MW parabolic trough CSP in Ordos, Inner Mongolia Autonomous Region. In 2011, the government approved licenses for an additional three utility-scale demonstration CSP projects in Gansu Province (50.0 MW), Qinghai Province (50.0 MW), and Ningxia Hui Autonomous Region (92.5 MW). These four demonstration projects are expected to start construction in late 2013 or early 2014. They will provide valuable hands-on experience and mitigate some of the perceived and real technology risks associated with first-of-its-kind projects, which will lead to large-scale CSP deployment in the country. CSP projects in the PRC, including those at the planning stage, are shown in Table 2.

Table 2: List of concentrated solar thermal power projects and status in the People's Republic of China

No.	Location	Capacity (MW)	Storage (hours)	CSP Technology	Status
1	Ordos, Inner Mongolia	50.0	4	Parabolic trough	Concession awarded
2	Delingha, Qinghai	50.0	7	Parabolic trough	Licensed
3	Jinta, Gansu	50.0	1	Parabolic trough	Licensed

[8] ADB. 2011. *Final report on Renewable Energy Development in Qinghai*. Consultant's report. Manila (TA 7643-PRC).

No.	Location	Capacity (MW)	Storage (hours)	CSP Technology	Status
4	Yanchi, Ningxia	92.5	0	ISGCC	Licensed
5	Germu, Qinghai	50.0	---	Parabolic trough	Licensed
6	Delinha, Qinghai	50.0	---	Parabolic trough	Licensed
7	Shannan, Tibet	50.0	---	Parabolic trough	Licensed
8	Dengkou, Inner Mongolia	50.0	---	Parabolic trough	Licensed
9	Bozhou, Xinjiang	59.0	---	ISGCC	Planning
10	Jiayuguang, Gansu	10.0	---	Parabolic trough	Planning
11	Germu, Qinghai	50.0	---	Heliostat tower	Planning
12	Jiayuguang, Gansu	10.0	---	Hybrid (with coal)	Planning
13	Turpan, Xinjiang	50.0	---	Parabolic trough	Planning
14	Turpan, Xinjiang	300.0	---	Parabolic trough	Planning
15	Lhasa, Tibet	50.0	---	Heliostat tower	Planning
16	Delinha Qinghai	50.0	---	Heliostat tower	Planning
17	Sanya, Hainan	100.0	---	Heliostat tower	Planning
18	Aba, Sichan	100.0	---	---	Planning
19	Ruanling, Hunan	50.0	---	Parabolic trough	Planning
20	Ningxia	100.0	---	---	Planning

CSP = concentrated solar thermal power, ISGCC = integrated solar and gas combined cycle, MW = megawatt.
--- data not available
Source: CSP Today Global Tracker. http://social.csptoday.com/tracker/projects

3. ADB Sector Experience and Assistance Program

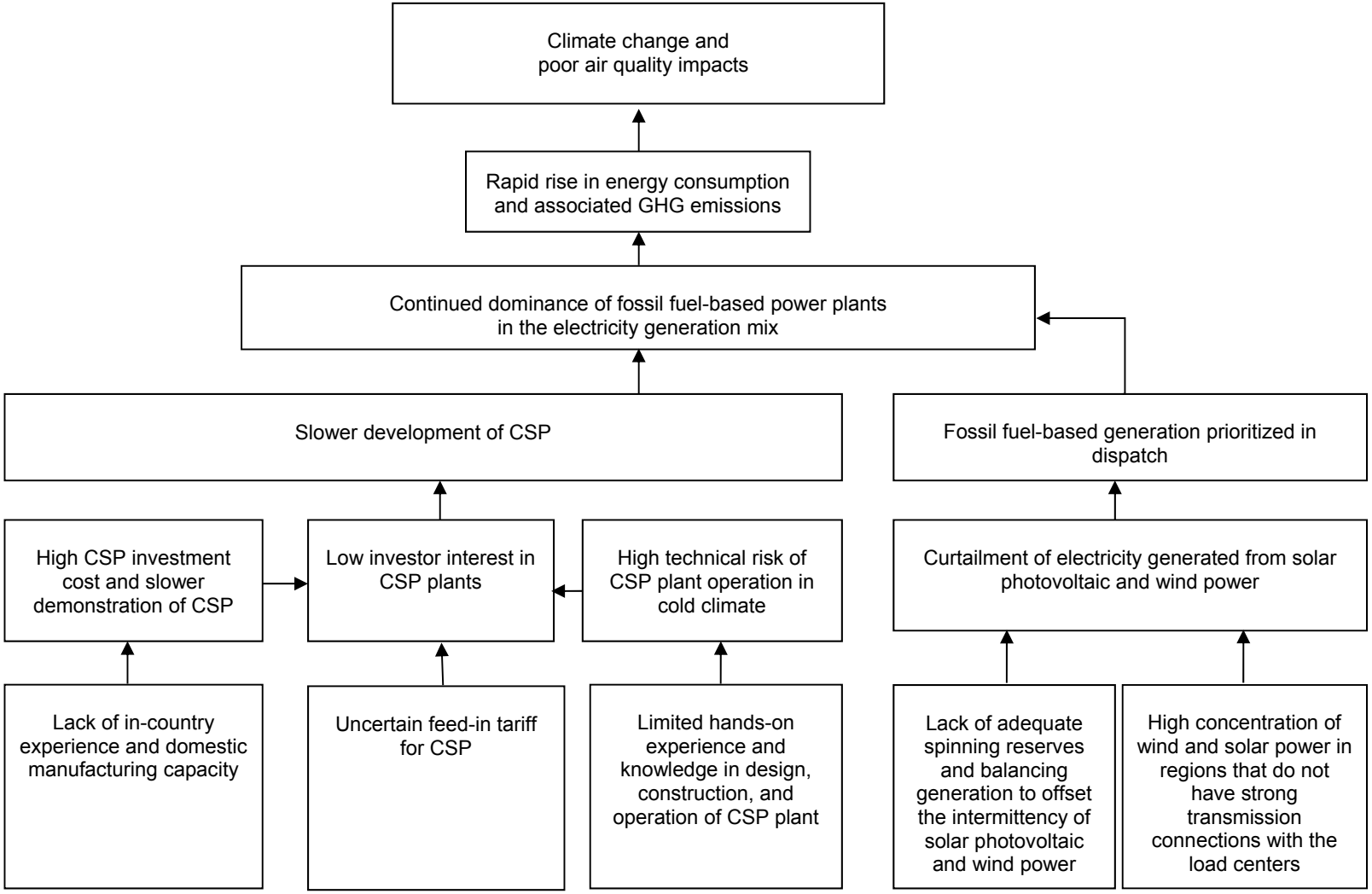
11. During the 11th plan period, 2006–2010, ADB played a lead role among international development partners supporting new technology and market innovations in the subsector, with 13 loans totaling about $2.0 billion, of which 37% were for new energy generation projects such as the first commercial-based integrated gasification combined cycle power, wind power, and waste to energy. Nonlending assistance of about $20 million focused on the development of cutting-edge technologies in clean energy and market innovation for emissions reduction, including carbon capture and storage, solar power (grid-connected solar photovoltaic and CSP), and smart grid.

12. Renewable energy development is a priority area in the sector road map under the country partnership strategy, 2011–2015 for the PRC.[9] ADB will support the development of new forms of renewable energy by financing technologies that are not yet commercially proven or widely used in the PRC (such as CSP, large-scale solar photovoltaic, and off-shore wind power), which are considered pioneers and are not mature enough to attract commercial financing.

13. ADB has been promoting CSP in the PRC since 2009 through capacity development TA (footnote 7. The TA has provided support in (i) developing a road map for CSP plant development in Gansu and Qinghai provinces, (ii) preparing a pre-feasibility study for a CSP project in Gansu Province, and (iii) implementing a pilot CSP project near Beijing. [10] In 2012, the government requested $150 million of ADB loan assistance for a 50 MW CSP demonstration project (parabolic trough with 7 hours storage and dry-cooling system) in Delingha, Qinghai Province, and $100 million of ADB loan assistance for a 50 MW CSP (parabolic trough with 1 hour storage and wet-cooling system) in Jinta, Gansu Province in 2013. ADB assistance to these two CSP projects, with different system configuration design and climatic conditions, will provide valuable lessons for standardizing technical specification, developing plant operation codes, and improving the tariff regime for further CSP technology scale-up.

[9] ADB. 2012. *People's Republic of China*: *Country Partnership Strategy, 2011–2015.* Manila
[10] This refers to 1 MW of Heliostat Tower CSP pilot plant in Yanqin County, Beijing, completed in September 2011.

Problem Tree for Energy–Renewable Energy Subsector



CSP = concentrated solar thermal power, GHG = greenhouse gas.
Source: Asian Development Bank staff estimates

Sector Results Framework (Energy Sector, 2011–2015)

Country Sector Outcome		Country Sector Outputs		ADB Sector Operations	
Outcomes with ADB Contributions	**Indicators with Targets and Baselines**	**Outputs with ADB Contributions**	**Indicators with Incremental Targets**	**Planned and Ongoing ADB Interventions**	**Main Outputs Expected from ADB Contributions**
Expanded nonpolluting energy into the primary energy mix, and reduced energy and carbon intensities	Carbon intensity reduced by 17% from 2010 levels (2010 baseline: 8.1 billion tons of CO_2 and CNY40 trillion of GDP) Energy consumption per unit of GDP reduced by 16% from 2010 levels (2010 baseline: 3.3 billion tce and CNY40 trillion of GDP) Share of non-fossil fuels in primary energy consumption reach 11.4% by 2015 (2010 baseline: 8.3%)	Energy sources decarbonized, diversified, improved, and well managed	Baseline: zero Power generation capacity increased from 496 GW in 2015 (2010 baseline: 255.5 GW, including 120 GW from hydropower, 70 GW from wind power, 45 GW from nuclear power, and 5 GW from solar power) Access to district heating system increased to 7.4 billion m^2 in 2015 (2010 baseline: 4.2 billion m^2) Access to district heating system to women maintained as a sex ratio in 2015 (2010 baseline: 51% male, 49% female)	Planned key activity areas: Clean energy (57% of lending in the sector) Energy efficiency and emissions reduction (43% of lending in the sector) Planned projects (2013–2015,: Clean energy ($250 million) Energy efficiency and emissions reduction ($250 million) Ongoing projects with approved amounts by the end of 2012: Clean energy (total of $135 million in one project) Energy efficiency and emissions reduction (total of $762.9 million in eight projects)	Innovative ADB projects will pilot test outputs that can be scaled up, including by 2015: 100 MW clean energy (solar thermal) generation facilities to be constructed Financial services for energy efficiency improvement to be made available in three provinces Total 450.5 MW of clean energy generation facilities to be constructed District heating system in three provinces to be improved

ADB = Asian Development Bank, CO_2 = carbon dioxide, GDP = gross domestic product, GW = gigawatt, m^2 = square meter, MW = megawatt, tce = ton of coal equivalent.
Source: Asian Development Bank estimates.